Method for producing compressed, plastic-coated rovings

The present invention relates to a method for producing compressed, plastic-coated fibers or rovings, consisting of substantially unidirectional parallel filaments. In particular, the present invention relates to a method for producing sized and compressed thin threads or tapes which consist of substantially parallel filaments which are used, for example, for producing sized thin threads, in particular saw threads for cutting out precise workpieces in the electronics industry, or for producing tapes and prepregs, fiber-reinforced plastic granules and fiber-reinforced shaped articles, and in extrusion.

The production of plastic-coated fibers and rovings which preferably consist of substantially parallel filaments, also in the form of tapes or prepregs, is known per se. Usually, rovings which consist of filaments are coated with a plastic or a mixture of plastics which may contain various additives and are processed in further processing stages, depending on the intended use, to give threads, granules, fiber-reinforced shaped articles or pultruded or extruded profiles.

Thus, it is known that rovings to be coated in the melt coating method can be passed through the melt of a thermoplastic, then allowed to cool and then further processed. When this method is used in practice, in particular in the case of a high proportion of fibers and increasing fiber length, however, a large variation in the strength values and numerous local weak points in the shaped article are found. Owing to the high shear forces, such as those which occur in melt impregnation, fine filaments, for example comprising carbon fibers, are broken and filament damage or tearing of threads occurs in the process. A similar situation is encountered with

the use of wet coating methods, i.e. of a liquid impregnating bath in which the plastic is dissolved in a solvent, in this case the difficulties associated with the evaporation of the solvent occurring in addition.

In the dry coating method, the rovings to be coated are preferably moved through a fluidized bed. This fluidized bed consists as a rule of a thermoplastic polymer powder in which additives are optionally incorporated (compounded), or of a curable thermosetting plastic powder or plastic powder premix, this being absorbed onto the fibers as a coating. It is also possible to apply the individual components of the coating in the fluidized bed method uniformly and directly to the fibers in the desired composition, the individual coating components present in the fluidized bed optionally additionally being mixed in the fluidized bed so that separation of the individual components is virtually prevented. Thereafter, the coated fibers are at least partly melted, preferably in a continuous oven, for example by means of IR radiation, and then cooled again. An improved distribution of the plastic on the fiber is thus achieved. However, this dry coating method has the disadvantage that a part of the powder used for the coating falls off the fiber again after emergence from the coating unit, with the result that the powder application and hence the proportion of resin and/or the proportion of filler in the end product is limited, which adversely affects the quality of the end product. However, the coating powder also falls off in the continuous oven and decomposes in contact with the overheated oven surface, resulting in the formation of decomposition products which enter the venting unit and the environment via the waste air. In addition, these particles, in the form of dust or in the form of decomposition products, also enter other parts of the production plant, in particular the filters of the venting unit, and block the filters of the venting unit

there. This in turn leads to imbalances in the operating procedure and the operating conditions, which adversely affects the quality of the coated rovings.

In all cases of said coating methods, a large variation in the strength values and numerous local weak points in the thread formed and hence also in the shaped article occur in practical use, in particular in the case of a high proportion of fiber. In particular, there are also local differences in the thread diameter and in the roundness or in the degree of roundness of the fiber and in the coating thereof with plastic, which subsequently causes said disadvantages. There is therefore a need to reduce or completely eliminate these disadvantages.

For the production of thin threads, in particular of saw threads for the electronics industry for cutting precise shaped articles, for example shaped articles which consist of silicon carbide, or wafers, chips and related shaped articles, or in the production of solar collectors, it is furthermore necessary for these threads to have been processed so as to be as thin as possible and very precise, i.e. of the same diameter along their entire length, the diameter of these threads being in the micron range, preferably in the range of 100-1000 microns (μm), and the variation in the linear deviation of the diameter from the required value should be within only a few microns. In this context, a very exact sizing of the threads is necessary, i.e. both the diameter and the roundness of the thread along the entire thread length are exactly established and monitored within the specified dimensions.

For the coating of rovings, in particular in powder coating, preferably linear unidirectional rovings are used, also in the present invention, i.e. rovings in which the filaments are arranged substantially parallel and substantially straight or

plane-parallel. These rovings can be more easily fanned out and hence more uniformly coated in the coating process.

It has now been found that thin plastic-coated continuous threads (consisting of a multiplicity of individual filaments) or those comprising plastic-coated fibers or rovings, consisting of substantially parallel filaments, are obtained if the rovings on which the plastic, optionally applied as powder, is present in the molten or liquid state are passed, after the coating, through a rotating device by means of which local rotation of the fibers is executed. As a result of such a local high rotation, the fibers are compressed to a high degree. In the process, the threads are twisted with one another, starting from the rotating device, backwards along the individual threads in the direction of the coating device. After passing through the rotating device, however, there are no longer any rotations or there are rotations only to a small extent, so that, after passing through the rotating device, the filaments have no spiral revolutions per meter or only a small number thereof but are arranged substantially parallel, linear and straight. Such threads can then be further processed, for example additionally coated with a suitable plastic and/or optionally with mineral particles and then hardened.
In a particular embodiment of the present invention, the rotating device consists of a rotating sizing die. By means of the rotating sizing die according to the invention, the fiber composite is additionally sized and particularly highly homogenized, and at the same time compressed, the enclosed gases being forced out of the composite. Sized rovings which have been processed to have an exact diameter along their entire length and have only a small linear deviation in the desired diameter length and hence a high degree of roundness and moreover are very compact or compressed result.

This gives excellent saw threads or coated rovings which have been processed exactly in the diameter or in the degree of roundness along their entire length, the variation in the linear deviation of the diameter from the required value being small. These saw threads are suitable in particular for producing shaped electronic articles, such as wafers, chips and related shaped articles.

In addition, there are the advantages that the material applied during the coating of the filaments is better distributed in the roving owing to the effect of the rotating device. Consequently, no material or only very little material falls off the coated fiber on entry into the continuous oven. As a result, material losses are reduced, the material consumption is optimized and the environment is protected, which is evident in particular on heating or on hardening the coating materials.

If a rotating sizing die is used, any melt cone is spun away by the rotating sizing die at its die edge and is not deposited dropwise on the thread. In accordance with the design of a sizing die, as shown below in figure 2a, any melt cone is spun away at the die exit. A sized thread of high density and free of air inclusions results.

By means of the method according to the invention, the proportion of filler in the coating premix can be substantially increased so that products having a lower proportion of fibers and higher proportion of fillers can be produced. The bulk density and the flowability of granules produced from such threads compressed according to the invention are also substantially increased, and the formation of tufts during granulation is considerably reduced.

By means of the method according to the invention, the tensile strength of the coated rovings in the production method itself is also increased to a surprisingly great extent and can readily be doubled. Thread breaks in the method, in particular in the area between the coating device and the rotating unit, are thus very substantially avoided even at high thread tension.

These unexpected advantages make it possible to carry out the entire method under significantly greater thread tension, which in turn permits a more balanced procedure and increased productivity of the production plant. Surprisingly, as a result of the local rotational effect produced by the rotating device, even relatively coarse powder particles having a particle size up to 300 µm remain enclosed in the composite in dry coating, so that uneconomical very fine milling of the polymers with narrow particle size spectrum can be dispensed with.

The invention is defined in the patent claims. In particular, the invention relates to a method for producing compressed, plastic-coated fibers or rovings, consisting of substantially parallel filaments, starting from rovings consisting of plastic-coated filaments, characterized in that rovings, or a plurality of such rovings as a composite, consisting of substantially parallel filaments on which the plastic applied, optionally as a powder, is present in the molten or liquid state, are passed, after the coating, through a rotating device by means of which local rotation of the fibers is executed so that the individual threads in the method are twisted with one another in the form of rotations, starting from the rotating device, backward along the threads in the direction of the coating device it being the case, however, that after passing through the rotating device there are no longer any rotations or there are rotations only to a small extent, so

that, after passing through the rotating device, the filaments have no spiral revolutions per meter or only a small number thereof, but are arranged substantially parallel and linear or straight.

The invention also relates to a particular embodiment for producing compressed, plastic-coated fibers or rovings, consisting of substantially parallel filaments, which is characterized in that the rotating device consists of a rotating sizing die, sized and compressed threads being obtained.

The roving treated in this manner or a plurality of such rovings as a composite can be subjected to further coating or subsequent coating. In this context, the invention also relates to a method which is characterized in that the rovings compressed according to the invention are subsequently coated in a subsequent coating procedure additionally with mineral powders or metal powders at temperatures above the melting point of the coating polymer, or with plastic, optionally as a mixture with mineral powders, and then hardened or allowed to solidify.

The present invention also relates to the use of the rovings compressed according to the invention, or a plurality of such rovings as a composite, for producing saw threads which are suitable, for example, for producing shaped electronic articles, preferably wafers, chips and related shaped articles, and for producing tapes and prepregs, fiber-reinforced plastic granules and fiber-reinforced shaped articles or fiber-reinforced pultruded or extruded profiles. Included therein are also fabrics which are woven from coated rovings and optionally then pressed. Tapes also comprise continuously produced fiber-reinforced tapes. Prepregs comprise unidirectional and fabric-reinforced prepregs.

The present invention also relates to the threads, saw threads, tapes, prepregs, fiber-reinforced plastic granules, fiber-reinforced shaped articles, fiber-reinforced pultruded or extruded profiles produced in this manner. The present invention furthermore relates to a device for carrying out the method according to the invention.

Said coated individual filaments or individual rovings as a composite may have been coated in the melt coating method, in the wet coating method and/or in the dry coating method, preferably in the dry coating method. The compression of the individual filaments or of the individual rovings as a composite is carried out in such a way that, after the coating process, the coated, individual filaments or individual rovings as a composite are passed through at least one rotating device, preferably a device which simultaneously sizes and compresses, such as, for example, a rotating sizing die, with the result that these filaments or the individual rovings as a composite are compressed on passing through or are simultaneously both sized and compressed by the rotating sizing die.

A suitable rotating device as indicated in figure 1 and shown more exactly in figure 2 may consist, for example, of two cooled shafts provided with V-grooves, which are arranged one behind the other at an angle of less than 90° (< 90°), preferably at an angle in the range from 5° to 20°. Preferably, the 1st shaft is arranged at an angle of more than or less than 90° to the thread direction, preferably at an angle of at least 91° or 89° (> 1°), preferably at an angle in the range from 60° to 120°. The second grooved shaft is arranged at right angles to the thread running direction. The coated roving runs through, for example, above the first shaft and below the second shaft, i.e. the rovings are passed over the first shaft and then under the second shaft, in each case in the

V-grooves thereof. In this case, the first shaft rotates counterclockwise and the second shaft clockwise. The V-groove of the first shaft is laterally offset in the thread axis by at least 1 mm, preferably at least 5 mm, so that the thread runs laterally over the oblique flanks of the first shaft. The thread is pressed against the V-flanks as a result of the angular arrangement of the shafts and as a result of the offset of the grooves and is rotated by the component acting perpendicularly to the thread axis, so that a clockwise or counterclockwise rotation of the thread results. The number of rotations (stated as rotations per meter) is determined primarily by the angle opening of the 1st shaft. The rotation of the grooved shafts is achieved by the friction with the coated rovings or additionally by an external drive. The number of rotations per meter is product-dependent and is determined by optimizing the angular arrangement and the friction of the coated roving in the V-grooves, which presents no problem for the person skilled in the art.

The rotating shafts are preferably mounted or installed after the first or optionally after a further continuous oven. The rotation acts uniformly, as already described above, over the entire length of the roving or rovings, back to the location where the roving leaves the coating device or, for the present example, the first rotating shafts. After passing through the rotating device, the rotations cease again and give the thread according to the invention with substantially parallel fibers, which have no rotations per meter or only a few thereof.

If a sizing die is used, it rotates at such a high speed that the individual filaments or individual rovings as a composite are compressed and also sized. All excess coating material which forms as a melt cone at the die exit is spun away during the sizing. The diameter of the sizing die is set so that the

desired thread diameter is obtained. As already mentioned, the threads in the method are rotated from the rotating sizing die in each case along the thread backward in the direction of the coating device. After passing through the rotating sizing die, there are, however, no longer any rotations in the forward direction or only a part of the rotations persist, so that, after passing through the rotating sizing die, the threads (filaments) have no spiral revolutions per meter or only a small defined number thereof.

The rotating die is preferably mounted or fixed in a hollow shaft and rotates together with this hollow shaft at a suitable speed of, as a rule, at least 500 revolutions per minute (rpm), preferably at least 2000 rpm, preferably at least 7000 rpm and preferably at about 10 000 rpm. A range from 7000 rpm to 15 000 rpm is preferred. The die, preferably produced from hard metal, is preferably heated to at least the melting point of the fiber coating, i.e. as a rule to at least about 100°C and preferably to about 150-180°C.

The polymer coating of the fiber must be liquid during passage through the rotating device, i.e. must be heated to a temperature which as a rule is at least 100°C and preferably at least 150-200°C or about 50°C above the melting point of the polymer. The heating can be effected, for example, by means of IR radiation or hot air.

It is also possible to connect a plurality of individual rotating sizing dies one behind the other in series and to pass the fibers through these devices. As a result, the fibers are even more accurately sized and compressed to a greater extent. Preferably, the sizing dies connected one behind the other have decreasing internal (sizing) diameters.

Preferably, the rotating sizing die has an internal diameter in the range of about 100-2000 µm (micrometers, microns), preferably in the range of about 150-600 µm and in particular in the range of about 200-350 µm, for example about 200-240 µm, with the result that a sized and compressed or homogenized and compressed strand produced according to the invention and having a corresponding diameter is obtained. The average linear deviation from the required value of the diameter of the hardened thread is as a rule less than 6% and preferably less than 4%, and is likewise in the micron range, which results in a very high degree of roundness.

The rotating device exerts a local torque on the fiber when it passes through. The rotating device is adjusted so that the roving has locally, for example depending on the rotational speed of the sizing die, about 5 to 50 spiral revolutions per meter, preferably about 10 to 30 spiral revolutions per meter, preferably about 10 to 20 revolutions per meter, before the rotating device. After leaving the rotating device, this local comparatively large number of revolutions per meter no longer exists, so that a roving comprising substantially parallel and straight filaments results. This means that the roving preferably has about 3 to 10 revolutions per meter and preferably still about 2 to 5 revolutions per meter. If a roving in which the individual filaments are arranged in parallel form was coated, the mutual parallel line of the individual threads is substantially retained in the compressed, preferably in the sized and compressed, roving.

Regardless of the compression, preferably sizing and compression, according to the invention of the roving or of the rovings, the sized and compressed rovings or thin threads can additionally be further processed in a manner known per se, for example to give thicker and stronger threads.

According to the invention, all fibers known per se which are known for the production of fiber-reinforced materials can be used as fibers from which the rovings are formed. Examples are synthetic inorganic fibers, in particular glass fibers, C fibers, plastic fibers, in particular aramid fibers (aromatic polyamide), zylon fibers (PBO) 28 dtex (0.028 g/m), or natural fibers, in particular cellulosic fibers. The filament thickness is preferably about 5 µm to 20 µm and about 100 tex-4800 tex (0.1 g/m-4.8 g/m), preferably 600 tex-2400 tex, as usually used.

According to the invention, thermoplastics known per se (as compound or as a premix) and/or thermosetting molding materials known per se (preferably as a premix) can be used as plastic for the coating. Thermoplastic molding materials or plastics and additives thereof are known in large numbers from the literature. Synthetic thermoplastic polymers are preferably selected from the group consisting of the polyolefins, preferably polyethylene, in particular HDPE, or polypropylene (PP); polycarbonates; polyoxymethylenes (POM); polyethylene terephthalates (PET); polybutylene terephthalates (PBT); polyethylene sulfides (PES); polyphenylene oxides (PPO); polyphenylene sulfides (PPS); PSO; PVDS; thermoplastic polycondensates, preferably polyesters and polyamides, such as polyamide 66, polyamide 12 and the like; polyvinyl acetates; polystyrenes; polacrylates; polymethacrylates; alkylene/acrylic acid copolymers or alkylene/methacrylic acid copolymers, preferably ethylene/acrylic acid copolymers; PEEK and PEK, alkylene/maleic anhydride copolymers; or alkylene/vinyl alcohol copolymers. HDPE, PP, polycarbonates, POM, PET, PBT, PES, PEEK, PEAK, PPO, PPS, PSO, PVDS, and thermoplastic polyamides are preferred. Synthetic polymers having a softening point of 100°C or higher, preferably in the range from 140°C to 390°C

and in particular in the range from 150°C to 350°C are preferred.

Thermosetting plastics in the form of polycondensates are, for example, curable phenol/formaldehyde plastics (PF casting resins), curable bisphenol resins, curable urea/formaldehyde plastics (UF molding materials), polyimides (PI), BMI molding materials and polybenzimidazoles (PBI). Thermosetting plastics in the form of polyadducts are, for example, epoxy resins (EP), molding materials comprising unsaturated polyester resins (UP molding materials), DAP resins (polydiallyl phthalate), MF molding materials, e.g. curable melamine/phenol/formaldehyde molding materials or crosslinked polyurethanes (PU).

For example, in addition to the resin/curing agent/accelerator system for thermosetting plastics, additives for thermosetting plastic molding materials or plastics and thermosetting plastics in the form of polycondensates or polyadducts are mold release agents, lubricants, fillers, pigments, adhesion promoters, stabilizers and inhibitors. Such compounds are known per se, as are the compositions preferably to be used for the coatings according to the present invention.

Said plastics may be applied to the rovings in the melt method or directly from the melt or in the wet method, i.e. in solution in a suitable solvent, or in the dry coating method, as described at the outset, as a coating, by means of a suitable apparatus known per se. Such devices and the process conditions are known to the person skilled in the art.

If the rovings which have been compressed, preferably sized and compressed, according to the invention, or a plurality of such rovings as a composite, are subjected to subsequent coat-

ing, said plastics and said coating methods can be used independently of one another, depending on suitability and choice. The plastic may additionally be used as a mixture with mineral or metallic, preferably crystalline, compounds and may serve as a binder for the mineral substances. Such subsequent coating is necessary in particular for producing saw threads. Such mineral substances are preferably crystalline compounds, preferably inorganic compounds, preferably oxides, carbides, metal powders, preferably in powder form. For example, inorganic compounds, such as oxides, carbides, preferably in powder form, such as, for example, magnesium oxide, aluminum oxide, silicon carbide, or other substances of great hardness, such as, for example, crystalline carbon, preferably diamonds, in particular industrial diamonds, preferably in the form of diamond powder, are preferred. The particle size of the powder is preferably in the range of about 5 µm-300 µm (microns), preferably in the range of about 10 µm-100 µm and in particular in the range of about 10 µm-30 µm. Synthetic polymers having a softening point of 100°C or higher, preferably in the range from 140°C to 390°C and in particular in the range from 150°C to 350°C are preferred for the subsequent coating, the process temperatures used being the same as those described herein for the coating device.

The attached figure 1 illustrates a diagram of a device for the coating and subsequent coating, according to the invention, of a roving, containing three rotating sizing dies which are connected in series which, for example, first size the thread to 300 µm and then to 260 µm and then to 240 µm and simultaneously compress it.

Figure 2 shows a rotating device containing two cooled shafts which are provided with V-grooves and are arranged one behind the other at an angle of less than 90°.

Figure 2a shows a rotating sizing device, containing the rotating sizing die, in cross section.

Figure 3 and figure 3A show a rotating sizing die with shear part, consisting of a cone for the melt cone A, the centering hole B, the transverse hole D, the shallow channel C, the bearings E and F and the toothed ring G. The roving coated with the molten premix passes through the centering hole B into the die, expands in the transverse hole D and emerges again through the shallow channel C. For filaments particularly sensitive to breaking or for exact sizing, only round dies are used, in order thereby to keep shear forces small. In this process, the die rotates at 6000 to 15 000 revolutions per minute. The changed cross section results in a shear effect and exertion of a rotational force. The inner filaments are substantially better opened up. A homogeneous strand having uniform resin content is thus obtained. This is more compact and can be granulated to give better granules. The density of the strand is higher. The coated strand is compressed by the rotation and by the shallow channel up to the coating, so that the coated strand passes through the IR oven without loss of coating particles. The toothed ring makes it possible to arrange different sizing dies in a line side by side in a small space and to drive them mutually. Analogous results are obtained with a rotating device according to figure 2.

Figure 4 shows a further embodiment of the sizing die, analogous to that shown in figure 3 and figure 3A, but the shallow channel B is narrower than the channel designated as sizing hole C.

The device (1) shown as attached figure 1 consists of an unwinding device (2), the coating device (3), the IR ovens (4),

the subsequent coating device (5), the rotating devices (6) according to figure 2 or 2a, the rotating device (6) preferably being a rotating device according to figure 2a, the conditioning device (9) and the winding unit (10). The first rotating device is mounted directly after the coating device (3). Further rotating devices or sizing devices are then mounted at the first IR oven (4).
If the coating device (3) is a device for the dry coating method in the fluidized bed, the particle size distribution of the coating component or of the coating components in the dry coating is preferably in the range of 30 µm-250 µm, preferably in the range of 50 µm-300 µm. The average particle size is chiefly preferably about 50 µm-150 µm.

For the coating, according to the invention, of rovings in the dry coating method with a reaction resin, such as, for example, an epoxy resin, a melting point in the range of 60°C-300°C, preferably 70°C-220°C, a roll temperature of 10°C-200°C, preferably 20°C-50°C, and a thread speed of 3-200 meters per minute, preferably 50-150 meters per minute, are preferably used. The processing conditions for the various plastics are known per se and also depend on the size of the apparatus used and can readily be correctly applied by the person skilled in the art for the respective plastic used or for the respective resin used.

In the powder coating method itself, the rovings are unwound from a roving rack, preferably from the outside of the roller, and fed into the coating unit, where they are preferably fanned out and passed through the fluidized-bed bath. The fluidized-bed bath comprises in principle a trough and contains the feed for the coating component or coating components, and the fluid base, which preferably consists of sintered aluminum or ceramic and through which the air supply to the fluidiza-

tion tank, i.e. the fluidizing air for maintaining the fluidized bed, is introduced. The diameter of the perforations in the perforated intermediate base (fluid base) is less than the particle size of the coating powder used or of the coating components or of the granules. Air or inert gas is blown in from below through the perforations, so that an undulating bath of powder or of granules or a fluidized bed forms. A plurality of deflection rollers or deflection rods for fanning out and tautening the fibers is present in the fluidized-bed bath. The coating unit can be provided with a device for additional thorough mixing of the coating components, for example a mixing device for additional mechanical mixing of the coating components.

The temperature of the air supply to the fluidizing tank, i.e. the conditioning of the fluidizing air, is controlled in proportion to the melting point of the polymer powder. Thus, the amount of powder applied can be controlled. A fluid base comprising sintered aluminum or ceramic is preferably used. The conditioning of the fluidizing air makes it possible to preheat those plastic powders having a high melting point during the coating itself to below the softening temperature and thus to reduce the required heat-up time. Thus, the productivity in the case of thermoplastics having a high melting point can be considerably increased. However, the heating during the conditioning may be effected in the case of reactive resin mixtures only to sufficiently below the temperature (onset temperature) at which the exothermic curing process of the resin mixture starts.

After the coated rovings have left the fluidized-bed bath, they pass through the rotating device according to figure 2 or the rotating device according to figure 2a. The rotating device according to figure 2a is a rotating sizing device con-

taining a rotating sizing die (7) which is produced from hard metal and by means of which the filaments are simultaneously both sized and compressed while passing through. The sizing die (7) is fixed in a hollow shaft and rotates together with this hollow shaft. The rotating hollow shaft can be driven by electric drive or compressed-air drive known per se. The sizing dies can also be integrated in gear wheels, the individual gear wheels engaging in one another in line and driving one another. That design of the sizing device or sizing die which is shown in figure 2a is only one of the possible embodiments.

After the first rotating device or sizing device (6), the coated rovings are passed through an IR oven (4) or a continuous oven, where they are heated. For this purpose, the continuous oven preferably contains an infrared heater. The coating becomes slightly liquid or pasty, but not so liquid that it can drip off the fibers. In this state, further coating material or granules which consists of consist of inorganic powder or of inorganic powder mixed with organic polymer, or of organic polymer, as described above, can be applied, optionally by means of subsequent coating, in a further coating device (5). The coated, heated thread can also be passed in this manner through fluidized mineral or metal powder, this powder being entrained by the softened coating polymer. The temperature and the residence time determine the layer thickness of the applied material. Subsequently, treatment can be effected in a further IR oven. In this way, the desired amount of plastic and/or inorganic material which is to be applied to the fibers can be reached. It is thus possible to obtain thread weights with a very low proportion of glass, for example threads having a proportion of only 15% by weight of glass fibers. The subsequent coating can also serve as insulation.

After the rovings have been coated, sized and compressed and optionally subsequently coated, they are then passed through a conditioning device (9) which consists of a cooling device and optionally a heating device. If an epoxy resin mixture was applied as a coating, the rovings are optionally heated again, the epoxy resin mixture undergoing pregelling or precrosslinking, but not being cured. The cooling is necessary in particular because the fiber/plastic composite is subsequently drawn through a pair of rolls which transports this composite. At the location of the pair of rolls, the fiber/plastic composite must be in a solid state, since otherwise the plastic may adhere to the rolls of the pair of rolls, with the result that these would become soiled and in certain circumstances reliable transport of the fiber/plastic composite would be hindered. Preferably, the fiber/plastic composite also passes through a heating device in which the temperature required for the granulation or winding is determined. The coated roving obtained can then be wound up or granulated.

If a pultrusion die is used, the apparatus preferably has the following structure:

Creel → coating bath → IR oven → rotating/sizing device → pultrusion die → profile take-off unit.

The present invention also relates to a device for carrying out the method according to the invention, comprising at least one coating device (3) for coating the roving or the rovings in the melt coating method or in the wet coating method or in the dry coating method, at least one IR oven (4) as a continuous device (for the wet and in the dry coating method) for fixing the coating, optionally a subsequent coating device (5), optionally associated with a further IR oven (4), and at

least one conditioning device (9), consisting of a cooling device and optionally a heating device for final conditioning of the coated thread, characterized in that at least one rotating device according to the invention, preferably a sizing device (6), are installed in the region after the coating device (3), but before the conditioning device (9) and before any subsequent coating device (5) present, the coated individual filaments from which the respective roving is formed, or the roving, or a plurality of such rovings as a composite, being compressed, or compressed and sized, by the rotating device or sizing device (6), immediately after leaving the coating device (3), and forming a compact closed strand.
The following examples illustrate the invention.

Example 1

PBO roving containing 160 filaments having a filament diameter of in each case 0.005 mm, 0.012 mm and 0.014 mm (5 µm, 12 µm and 14 µm) are coated in the dry coating method with a matrix which contains a customary bisphenol resin (Araldit®) and curing agent (Durez®) from Hunstmann und Durez, (50.0% of the total coating), and customary mold release agents, lubricants, fillers and pigments (50.0%) in a customary composition. The components of the matrix are mixed in a mixer and have a particle size distribution in the range from 30 µm to 200 µm. The coating method is carried out an apparatus described above in the description, a coating unit described in EP-A-0 680 813 being used. A sizing device containing a rotating die mounted in a hollow tube and intended for the continuous simultaneous sizing and compression of the rovings is installed directly after the coating unit. This sizing device corresponds to the device shown in figure 2a. The die has an internal diameter of 300 µm. A second and a third such sizing device having in each case a die diameter of 260 µm and 240 µm are mounted in series after the continuous IR oven.

Glass rovings are unwound from a roving rack, preferably from the outside, fanned out and passed via four deflection rods to the fluidized-bed bath. The coated rovings then pass through a sizing device, then the continuous infrared oven at a temperature of 180°C and then the two further rotating sizing devices connected in series. The coated rovings are then conditioned in the conditioning unit and cooled so that the plastic becomes solid.

Coated rovings having a diameter of 240 µm and a deviation of the diameter over the length of the thread of less than 0.5% were obtained. Virtually no evolution of smoke from decomposed coating material in the continuous oven and in the conditioning unit was observable. The thread speed (throughput) was 140 meters per minute.

Example 2

Example 1 is repeated, with the proviso that, instead of the sizing devices according to figure 2a, (i) only one rotating device according to figure 2 and (ii) first a rotating device according to figure 2 and then a sizing device according to figure 2a are installed. Here too, good results analogous to those in example 1 are obtained.

Example 3 (comparative example)

Example 1 is repeated, with the proviso that the installation of the sizing device (6) is dispensed with. Coated rovings having a diameter of about 300 µm and a deviation of the length of the thread of 15% were obtained. Evolution of smoke from decomposed coating material in the continuous oven and in the conditioning unit was observable. The thread speed (throughput) was 80 meters per minute.

Example 4

Example 1 is repeated, with the proviso that the bisphenol resin and the curing agent and the additives are replaced by a PEEK-HT (Vitrex®, from Victrex) having a melting point of 370°C. Results analogous to those stated in example 1 are obtained.

Example 5

Example 1 is repeated, with the proviso that the bisphenol resin and the curing agent and the additives are replaced by a thermoplastic polyamide 11 powder having a melting point of 180°C. Results analogous to those stated in example 1 are obtained.

Example 6 (comparative example)

The examples 1, 2, 4 and 5 are repeated, with the proviso that the installation of the rotating device or of the rotating sizing devices according to the invention is dispensed with. Here too, the results from examples 1, 2, 4 and 5 are substantially superior to the results from example 6. In the method according to examples 1, 2, 4 and 5, the thread quality and the loss of coating material were considerably smaller than in example 6. The bulk density of granules obtained according to examples 1, 2, 4 and 5 was also markedly higher than that according to example 5. The throughput, too, is substantially higher in examples 1, 2, 4 and 5 in comparison with example 6.